A NATURALISTIC MODEL OF KILAUEA VOLCANO, HAWAII*

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There has recently been placed on exhibition in the Geological Section of the Harvard University Museum a large and remarkably naturalistic model of Kilauea, the active crater on the eastern slope of Mauna Loa, the great volcano on the island of Hawaii. It is the work of Mr. George Carroll Curtis of Boston and embodies the ripe fruition of his many years of effort in the production of relief models that are true to nature. In some respects a study of this model will give to the student a clearer understanding of the great crater than he could obtain from pictures, descriptions, or even a visit to Kilauea itself.

The work on the model was begun in March, 1913. Mr. Curtis went to Hawaii and spent three months at the crater, making a careful photographic survey, supplemented by elaborate field notes, color sketches, and detail drawings.[1] Mr. F. W. Haworth devoted several months to the making of a series of aërial photographs of Kilauea from kites half a mile or more above the ground. The working up of the material gathered and the execution of the model consumed forty months in all.

The model, which is of circular form, with a diameter of fourteen feet, is on the scale of 1:1,500, or 125 feet to the inch. The underlying conception of the model implies that there is no vertical exaggeration. The extensive encircling cliff around the lava "sink" has, in the model, a height of from two to six inches, while the great caldera measures about ten feet across. The purely mechanical work of building up the raised map which forms the basis of the model took six months and the coloring about the same length of time. The incorporation of the vast amount of detail from photographic records, sketches, and field notes consumed the remainder of four years of careful personal work.

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* The writer wishes to express his appreciation of the valuable assistance rendered Mr. Curtis in his preliminary work while at Kilauea by Dr. T. A. Jaggar and Dr. H. O. Wood.

[1] G. C. Curtis: Work Going on at Kilauea Volcano, *Science*, Vol. 38, 1913, pp. 355-358.

EXPLANATION OF FIG. 1—The observer looks northwest across the great lava "sink," in which, on the left, is the active pit of Halemaumau (House of Eternal Fire). The rim of the caldera is seen almost in its entirety from the northeast around to the southwest. In the distance, the cone of Mauna Kea and the long gently dipping slopes of Mauna Loa. In the foreground, Keanakakoi Crater and the border of the Kau desert; smaller extinct pit crater on the right. In the left foreground note the very young, consequent drainage system, cutting the ash-cover surface, and its intersection by lines of faulting. This stream system, unknown before, was brought out by the kite photographs made for the model. An opera glass facilitates locating on the model the "bomb" craters among these channels. The automobile road leading to the active crater may be traced.

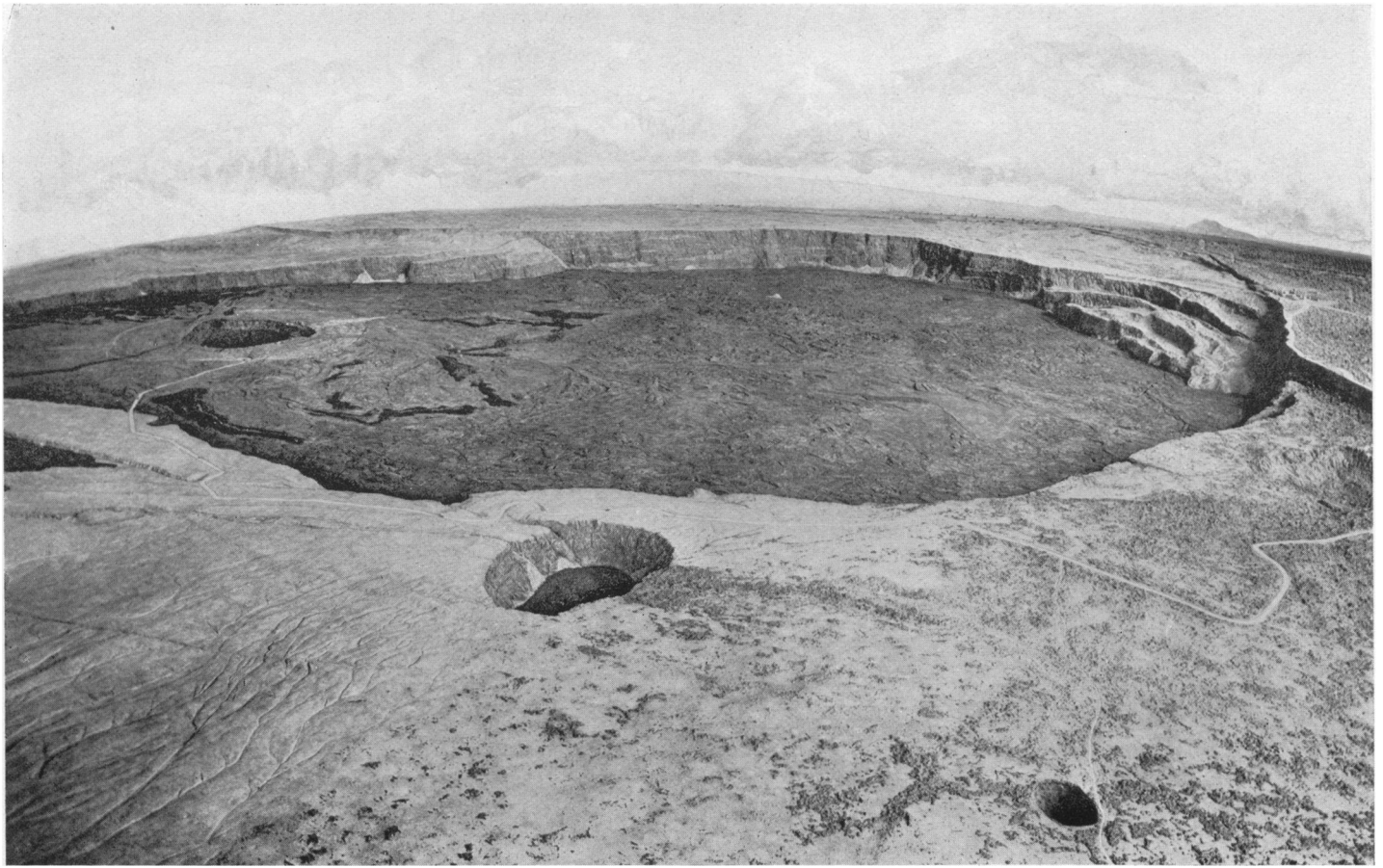

FIG. 1—Photograph of the Kilauea model, giving a general view of the crater. (For explanation, see bottom of opposite page.)
(Figs. 1, 2, and 3 from photos by Burr A. Church; descriptions by G. C. Curtis.)

FIG. 2—Photograph of the Kilauea model looking southwest over Volcano House across the lava sink. In the foreground is the forest, mostly *ohia* trees. The vegetation gradually fades out toward the active crater. The great escarpment may be followed, and in the middle distance lies Halemaumau, where, in the lake of molten lava, the legendary fire goddess Pele has her abode. The dark gray filling of the extensive caldera is built of multitudes of lava-flows, mostly the smooth, or *pahoehoe*, variety, the darker patches being the rough *a-a* (first brought out by the model). In the distance the dim outlines of Mauna Loa, 13,860 feet, may be seen. Note the old "horse trail" crossing the middle of the lava.

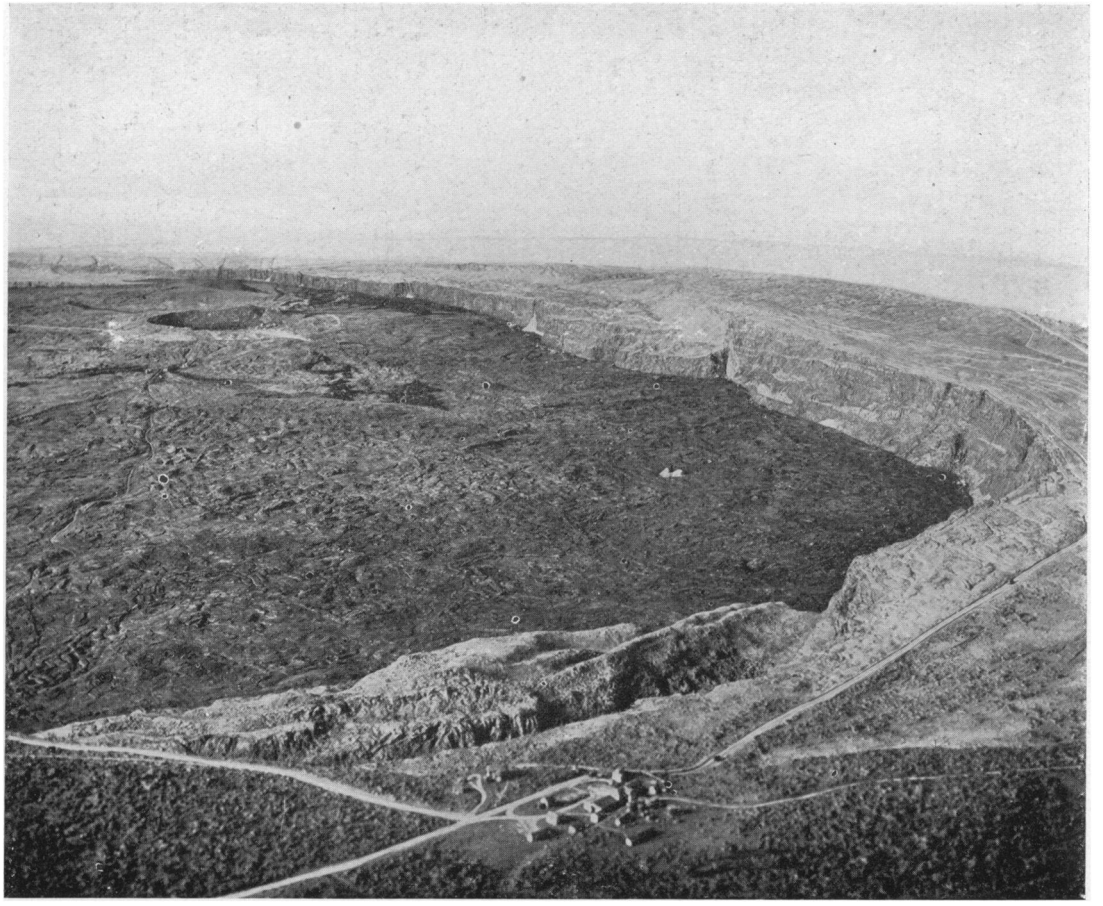

FIG. 3—Photograph of the Kilauea model looking northeast across the pit of Halemaumau, the molten lake with its fiery fountains being just visible. The liquid lava is 350 feet below the rim of the crater. The observation hut maintained by the Massachusetts Institute of Technology is on the left just back from the rim. Sometimes the molten lava rises nearly to the top of the pit, and again it will sink away so as to make the crater about a thousand feet deep. The dark gray lava field reaches to the base of the encircling caldera walls, in which the old bedded structures of ancient lava-flows, ash beds, and a laccolith may be observed. Talus is seen in several localities at the base of the escarpment. In the left foreground is the summit point Uwekahuna, under which lies a stairway of great down-faulted blocks. Note the Volcano House group of buildings in the right distance, to the left of which is the brilliantly colored Sulphur Bank and, behind, the dark forested slopes of the Kilauea cone.

The most notable relief model of a similar nature made in the United States before this was a model of the coral island of Bora Bora, made by Mr. Curtis at the suggestion of Alexander Agassiz to illustrate a typical high coral island, and installed in 1907 in the Harvard University Museum. It was the first important work of its kind undertaken in America and was based upon photographic and other special surveys. This model and the general question of naturalistic models and their educational value were discussed by Mr. Curtis in an article entitled "Land Reliefs That Are True to Nature" in the *Bulletin of the American Geographical Society* for June, 1911.[2]

Habitat groups of animal life have become almost a necessity in up-to-date museums, but before the work of Heim in Switzerland and Curtis (who studied under Heim) in America natural representation of earth forms had not been developed. The Bora Bora and the Kilauea models in America, therefore, mark the beginnings of what may be called a new art. While zoölogy and botany have been profiting for some years by the naturalistic or habitat specimens, the development of natural land relief types has nowise progressed to the same extent. It seems to the writer that the main reason for this slow progress is the difficulty of finding individuals who possess the qualifications necessary for such work. To do the work which Curtis is doing one must be a geologist and geographer first of all, and, in addition, an artist, surveyor, photographer, and sculptor. To find the combination of all these accomplishments in one person is difficult indeed. The high cost of the models also has hindered the progress of this work. With kite or airplane photographs, however, the cost of the work will undoubtedly be cut down one-third, or perhaps one-half, and the time necessary to make an elaborate model will also be reduced in proportion. Instead of requiring nearly four years, the Kilauea model, Curtis calculates, could have been finished easily in two years or perhaps much less, had he been in possession of these bird's-eye views during the first year. As it was, the kite views were not obtained until the third year of the work.

A decade has passed since Bora Bora was finished. During that time several new steps in the art have been taken. The first was the use of a revolving panoramic camera, by which five continuous miles of the Kilauea walls were brought into one view on the full scale of the model, assuring complete and accurate modeling of the intricate and seemingly infinite detail of the complicated outcropping structures. The second was the use of aërial photographs, without which reproduction of the forms of the vast and complicated lava floor would hardly have been possible. This lava sink alone took a year of modeling. Features never before observed, like the drainage system on the southeast, the location and distribution of fault cracks and of bomb craters, were first brought to notice by these photographs, although previously the region had been much examined. A third

[2] Vol. 43, 1911, pp. 418-427.

innovation is the cycloramic background, which in a highly satisfactory way solves the old and perplexing problem of how to treat a large area within the limits of museum space. This was accomplished by the addition of a background which continues the modeled area through the painting of the natural surroundings in perspective. This not only gives additional information but supplies the familiar, natural environment, lack of which has badly handicapped other work.

The result of all the various means which Curtis has used in the making of the Kilauea model speaks for itself when we view the finished work with or without an opera glass. The writer finds that a six-diameter field glass is even better than an opera glass. The effect is almost that of being at Kilauea itself instead of thousands of miles away.